

Late Cretaceous Ammonites from Central Saudi Arabia

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Abstract. Eight ammonite species from the Khanasir Limestone Member and the overlying Hajajah Limestone Member of the Aruma Formation in Central Saudi Arabia have been described and illustrated. Their ages and comparison with similar species are presented here. These ammonite species consist of *Pachydesmoceras* sp., *Pachydiscus* (*Pachydiscus*) *launayi* (*deGrossouvre*), *Metatissotia* cf. *ewaldi* (Von Buch), *Hemitissotia turzoi* Karrenberg, *H.arumaensis* sp. nov., *Manambolites amardi* Collignon and Roman, *Libycoceras chargense* Blankenhorn and *Libycoceras* sp. According to these ammonite species, the Khanasir Limestone Member is dated as Middle-Late Coniacian to Middle Campanian. The overlying Hajajah Limestone Member is dated as Upper Campanian. Tectonic tilt and possible global sea level drops during Late Coniacian are responsible for a hiatus and this includes Santonian-Lower Campanian in Central Saudi Arabia. The Campanian-Maastrichtian boundary in ammonite terms in Central Saudi Arabia is drawn here at a different level rather than on larger forams as it was previously based on.

Introduction

Bramkamp and Steineke (in Arkell [1]) gave the name "Aruma Formation" to the Late Cretaceous sequence that outcrops in Central Saudi Arabia. On the basis of its foraminiferal content, the Aruma Formation was considered by Powers *et al.* [2] and by Powers [3] to be of Campanian to Maastrichtian age. Subsequently, the Aruma Formation was subdivided by El-Asa'ad [4], [5], [6] into three members, namely the Khanasir Limestone Member overlain by the Hajajah Limestone Member and is followed by the Lina Shale Member (Fig. 1). He recognized nine faunal zones representing the Senonian to Maastrichtian stages in these rocks. From above the base of the Khanasir Limestone Member, El-Asa'ad [4],[5],[6] has named the *Tissotia* assemblage zone (Coniacian); the association of this zone includes *Tissotia tissoti* Peron, *T. arabica* El-Asa'ad, *T. sp.*, *Hemitissotia turzoi* Karrenberg, *H. sahbaensis*

El-Asa'ad and *Paratissotia* sp. The base of the Khanasir Limestone Member is a vuggy dolostone unit (0.5-3 m thick) that overlies fluvial deposits of the Al-Wasia Sandstone, and underlies the so called nodular limestone (40m thick). This nodular limestone forms a major portion of the Khanasir Limestone Member, it is comprised of different lithotypes, these are from bottom to top: burrowed limestones, intraformational conglomerates, mottled limestones and fractured bedded dolostones (El-Asa'ad [7]). Below the top of the Khanasir Limestone Member there is a rudistid reefal limestone unit 2-3 m thick. The Hajajah Limestone Member (77m thick) is composed of olive green shale (6m thick) overlain by a slightly dolomitic, chalky limestone (51m thick), followed upwards by a highly dolomitic limestone (20m thick). The upper exposed part of the Aruma Formation is composed of argillaceous limestone, passing laterally into arenaceous shale (the Lina Shale Member).

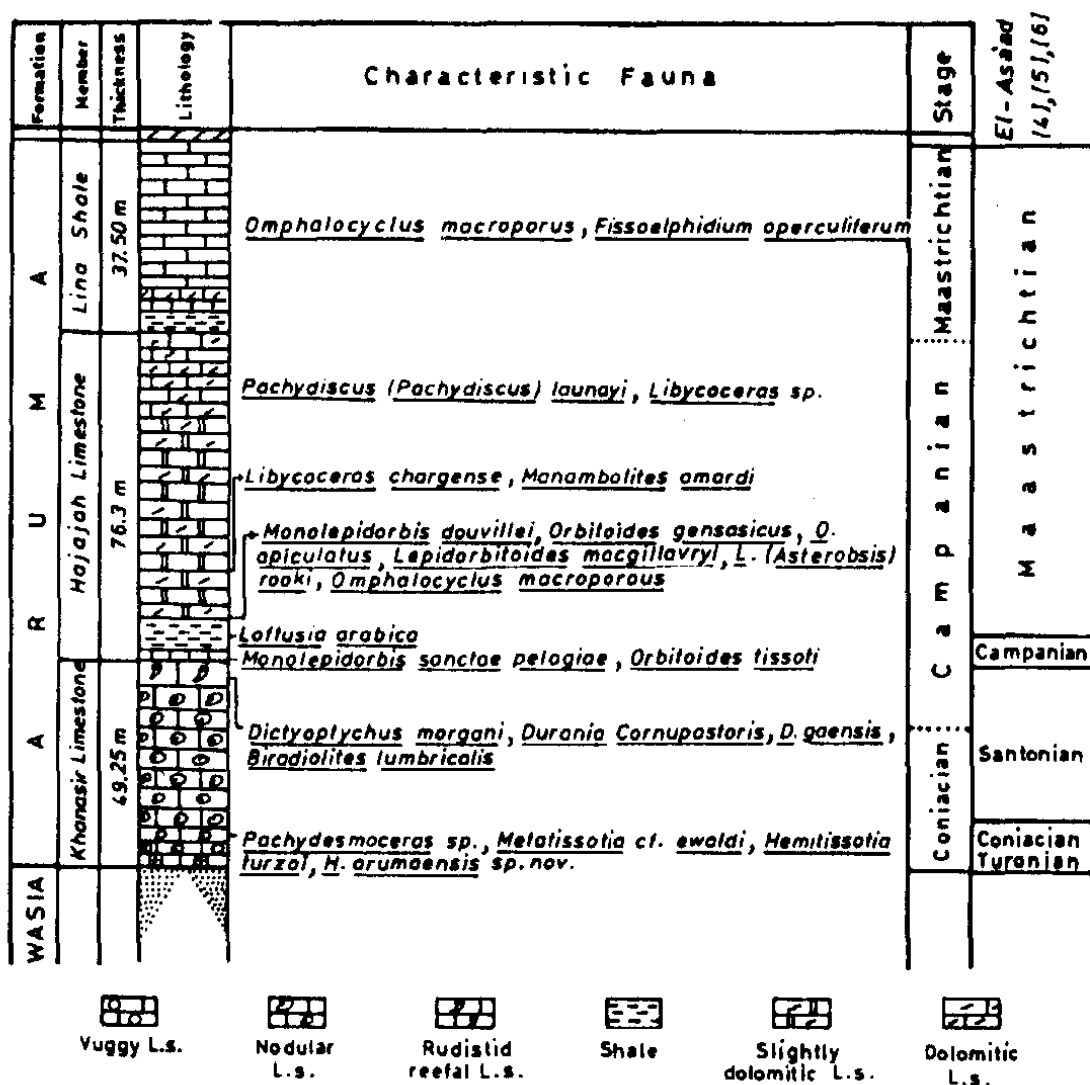


Fig. 1. Composite reference section of Late Cretaceous outcrops in Central Saudi Arabia.

The present study is based on recently collected ammonite material from Aruma outcrops in Central Saudi Arabia. This material was collected at the localities of Khashm Rudhai, Khashm Buwaibiyat, Khashm Khanasir, Khashm Hajajah and at the Aruma section cut by the old Riyadh-Khuraish road (Fig. 2).

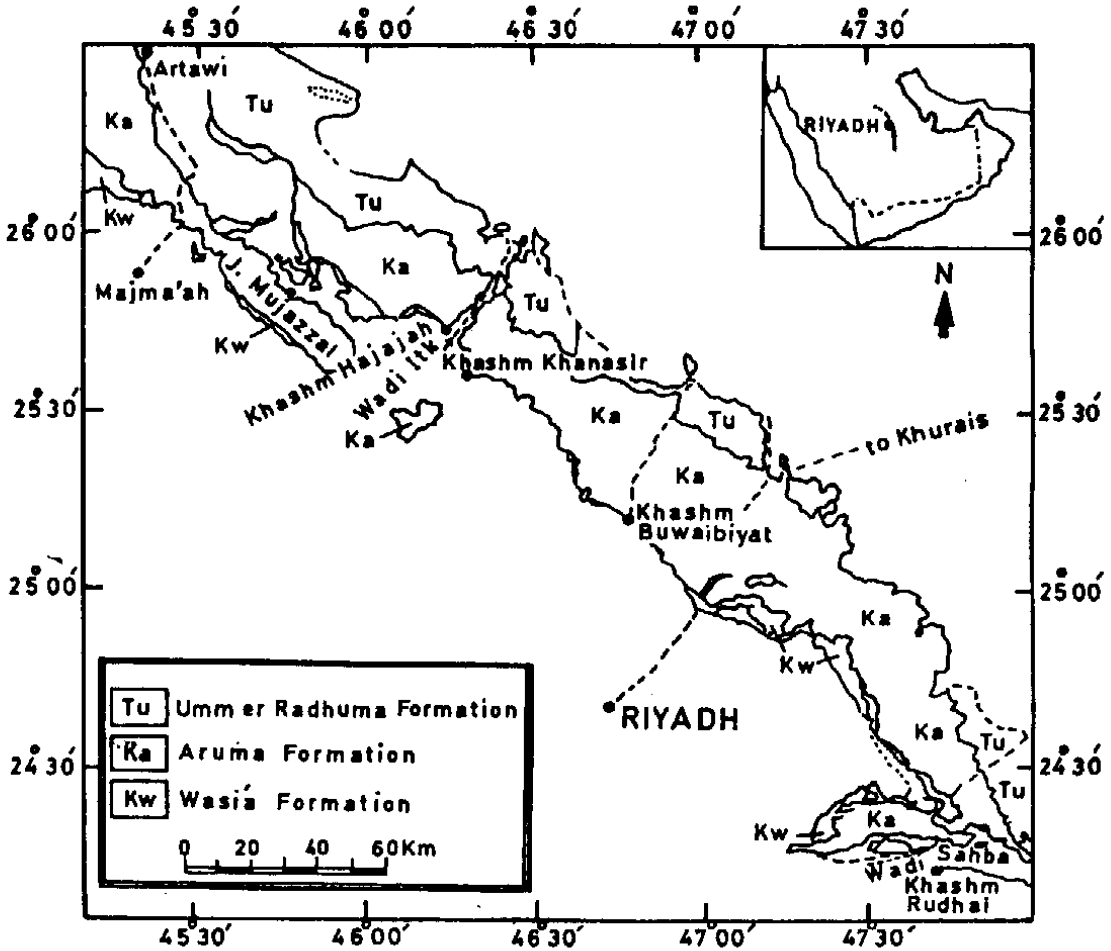


Fig. 2. Geologic map of the Aruma Formation in Central Saudi Arabia showing collection sites.

Systematic Palaeontology

The recently collected ammonite fauna from the Aruma Formation in Central Saudi Arabia consists of eight species belonging to six genera and five families. The collection is kept at the Geological Museum, Geology Department, King Saud University, Riyadh, Saudi Arabia under the numbers KSU. G. Amm. 50-62. Dimensions are given in millimeters in the following order; maximum diameter of the conch (Dm), whorl breadth (E), Whorl height (H), breadth of umbilical region (O), number

of ribs (N). I have followed Zaborski [8] in regarding the genus *Libycoceras* Hyatt, 1900 as belonging to the family Libycoceratidae Zaborski, 1982.

Suborder	:	<i>Ammonitina</i> Hyatt, 1889
Superfamily	:	<i>Desmocerataceae</i> Zittel, 1895
Family	:	<i>Desmoceratidae</i> Zittel, 1895
Subfamily	:	<i>Puzosiinae</i> Spath, 1922
Genus	:	<i>Pachydesmoceras</i> Spath, 1922

***Pachydesmoceras* sp**
(Text- Fig. 3)

Material

Two specimens of phragmocone (KSU. G. Amm. 50; KSU, G. Amm. 51) were collected from the Khanasir Limestone Member of the Aruma Formation at Riyadh-Khuras road and Khashm Khanasir.

Description

The specimens are medium to large, involute with fairly large and rounded umbilicus. Flanks are slightly inflated and converging ventrally. The inner flanks are worn. Whorl section is high, compressed to oval. Venter is narrowly rounded. Pronounced concave or arched strong ribs are on the external third part of the whorl and cross the venter. Suture line with four high saddles are separated by three deep jobs on each lateral side. These saddles are divided by a deep accessory lobe and are deeply denticulated on their sides. The 1st and 2nd lateral saddles are very high. The lobes are deep and trifold and the 1st lateral lobe is very deep. The 1st umbilical saddle and the 1st umbilical lobe are very small in proportion to other saddles and lobes. There are no visible constrictions on the ventral side; this may be due to mode of preservation (internal molds).

Discussion

Poor material collected from Central Saudi Arabia together with bad preservation make identification to species level inadvisable. It differs from *Pachydesmoceras* species that was described by Collignon [9] from Madagascar by having a higher whorl section. It is also different from those described by Matsumoto [10] from Japan by its ventral constrictions not being visible.

Dimensions		Dm	E	H	O	N
1	:	235	68	125	45	18
2	:	76	15	39	18	—

Family : *Pachydiscidae* Spath, 1922
Genus : *Pachydiscus* Zittel, 1884
Subgenus : *Pachydiscus* Zittel, 1884

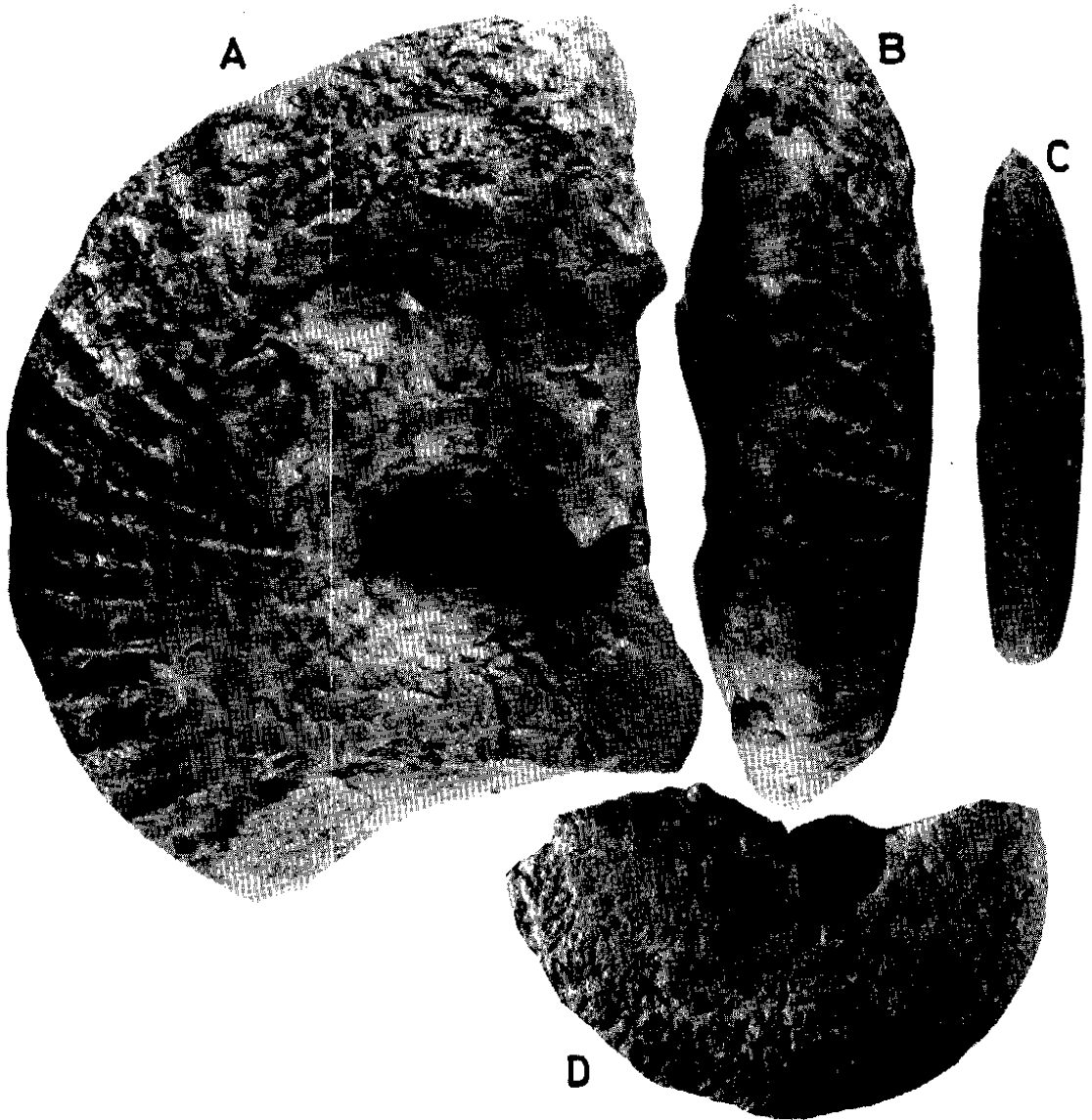


Fig. 3. *Pachydesmoceras* sp., KSU. G. Amm. 50, KSU. G. Amm. 51, from the lower part of the Khanasir Limestone Member, Coniacian, Riyadh-Khuraib Road and Khashm Khanasir.

- (A) KSU. G. Amm. 50, Lateral view of phragmocone, X-0.5
(B) KSU. G. Amm. 50, ventral view, X-0.5.
(C) KSU. G. Amm. 51, ventral view, X-0.9.
(D) KSU. G. Amm. 51, Lateral view of phragmocone, X-0.9.

Pachydiscus (Pachydiscus) launayi* (de Grossouvre, 1894)*(Text – Fig. 4)**

1986, *Pachydiscus (Pachydiscus) launayi*, (de (Grossouvre) Kennedy [11], p. 38, pl. 2, figs. 1,2; pl. 7, figs 6,7; pl. 10, fig. 15; pl. 13, figs. 2,3,6; text. figs. 4C and 5B.

1977, *Puzosia denisoni* Stoliczka, El-Asa'ad [4], p. 299, pl 21, figs. 1a-c.

Material

One specimen of phragmocone (KSU. G. Amm. 52) was collected from the Hajajah Limestone Member of the Aruma Formation at Khashm al-Hajajah.

Description

The specimen is large, moderately evolute with moderately wide, shallow or moderately deep umbilicus (30% of diameter). Umbilicus has a low, rounded and inclined wall. Whorl section is slightly depressed, with marked umbilical shoulder and greatest breadth is just outside the umbilical shoulder. The venter is broadly rounded. There are twenty to twenty five rounded primary ribs and these are arised from the umbilical wall and are extended over the ventro-lateral sides. They flex forward and cross the venter in a broad convexity. They are weaken slightly over the siphonal region and are interrupted at a narrow siphonal groove. Suture line complex and is poorly preserved.

Discussion

The present species differs from *Pachydiscus (Pachydiscus) oldhami* that was described by Sharpe [12] by having strong ventral and inner flank ornamentation; *P. (P.) oldhami* has smooth macroconchs (Naidin [13]). It differs from *P. (P.) holdemsis* (Schlüter) and Kennedy [11] by having a more inflated shells.

Superfamily	:	<i>Acanthocerataceae</i> Hyatt, 1900
Family	:	<i>Tissotiidae</i> Hyatt, 1900
Subfamily	:	<i>Tissotiinae</i> Hyatt, 1900
Genus	:	<i>Metatissotia</i> Hyatt, 1903

Type species. *Ammonitesourneli* Bayle [14], p. 360, pl. 17, figs. 1-5, by subsequent designations of Roman [15; p. 554].

Metatissotia cf. ewaldi* (Von Buch, 1848)*(Text – Fig. 5)**

cf. 1848, *Ammonite ewaldi* Von Buch [16], p. 221, pl. 1, fig. 4.

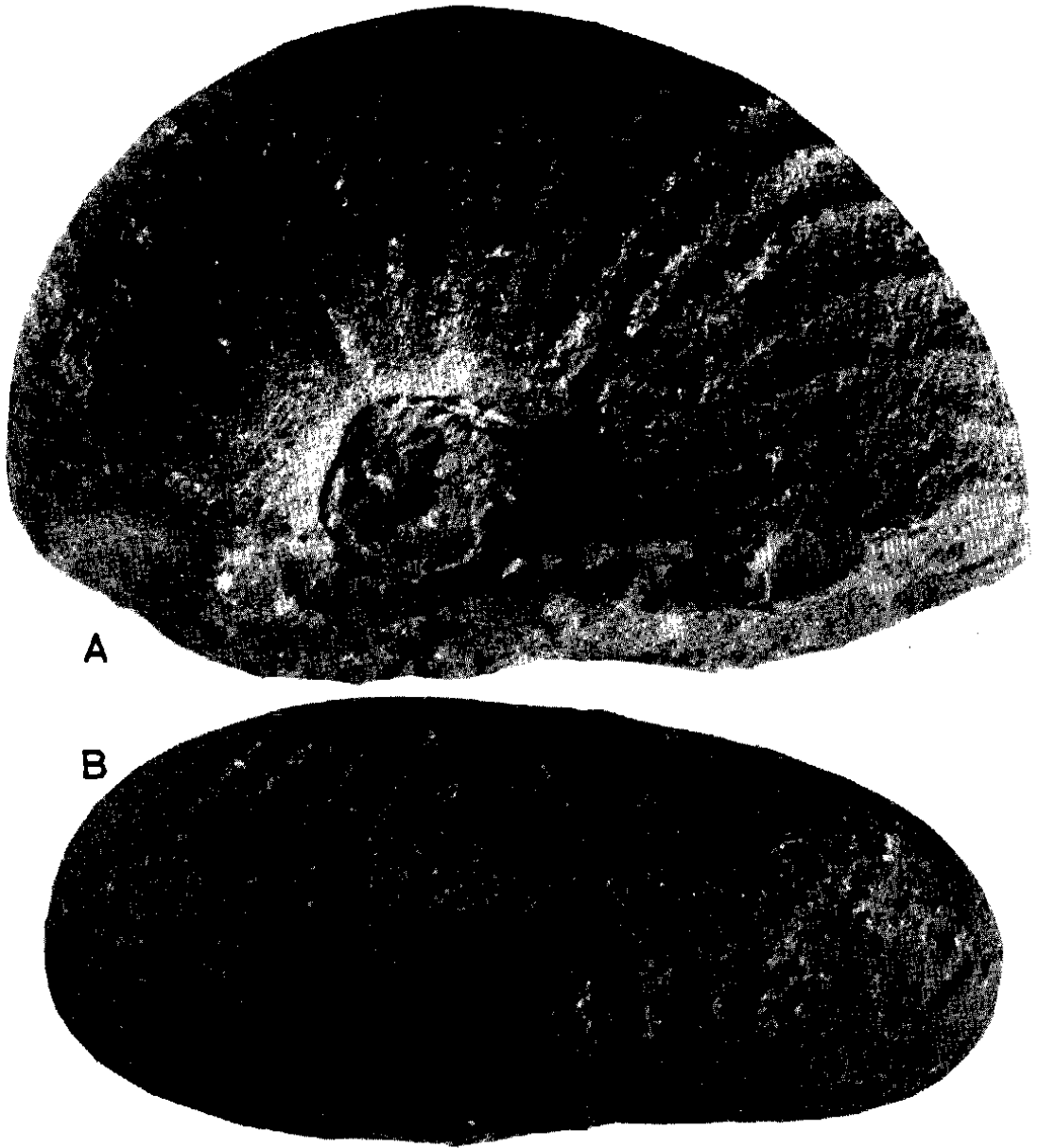


Fig. 4. *pachydiscus (Pachydiscus) launayi* (de Grossouvre)
 KSU. G. Amm. 52, from the middle part of the Hajajah Limestone Member, Upper Campanian,
 Khashm Hajajah.

- (A) Lateral view of phragmocone, X-0.6.
 (B) Ventral view, X-0.6.

cf. 1984, *Metatissotia ewaldi* (Von Buch), Kennedy [17]. p. 127, pl. 28, figs. 4,5;
 pl. 29, figs. 9-11; pl. 30, figs. 1,2,5-6, 8-9, 12; pl. 32, figs. 1-3.

cf. 1989, *Metatissotia* cf. *ewaldi* (Von Buch), Luger and Gröschke [18], p. 384, pl. 44, figs. 1,2; text. fig. IOE.

Material

Two complete specimens of internal molds (KSU. G. Amm. 53; KSU. G. Amm. 54) were collected from the Khanasir Limestone Member of the Aruma Formation at Riyadh-Khuraish road.

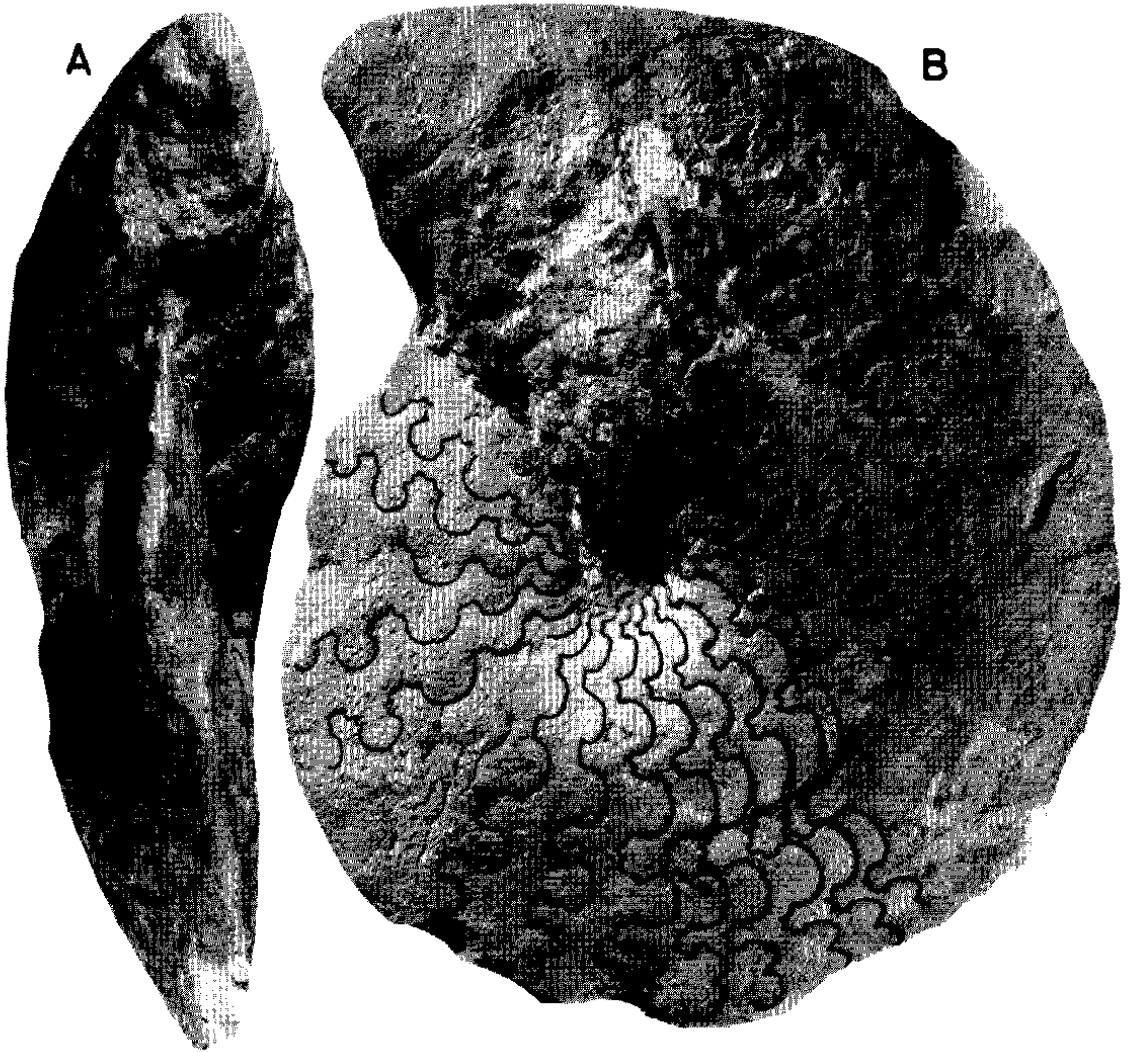


Fig. 5. *Metatissotia* cf. *ewaldi* (Von Buch) KSU. G. Amm. 53, from the lower part of the Khanasir Limestone Member, Coniacian, Riyadh-Khuraish Road.

(A) A pertural view of complete conch, X-0.6

(B) Lateral view of complete conch with body chamber, X-0.6.

Description

The specimens are moderately large mature conchs, very involute, smooth and concentrically coiled oxycones. Phragmocone is compressed. Body chamber is large with a length of about 1/2 of volution and the body chamber is inflated adorally and ends by a contraction or tapering at the apertural side. Ventral margin is nearly fastigiated and slowly become more or less adorally rounded. Umbilicus is moderately deep and wide. The umbilical shoulder is rounded with pseudoceratitic suture line; suture lines are crowded towards the end of phragmocone. The sutures have six saddles on each side. The 1st lateral saddle is divided into two equal to subequal parts by a notch. The other saddles are entire, low and broad. Lobes are narrow. The 1st and 2nd lateral lobes are deeper and more subdivided than others. No visible ornamentation is seen on the body chamber or the phragmocone.

Discussion

It differs from *Metatissotia* cf. *ewaldi* (Von Buch) which were described by Luger and Gröschke [18] P. 384, pl. 44, figs. 1,2; text-fig. IOE by having the body chamber more adorally inflated and by having a less rounded umbilical shoulder. It differs from *Metatissotia ewaldi* (Von Buch), that was described by Kennedy [17], p. 127 by having no visible ornamentation. It differs from *Tissotia* (*Metatissotia*) *singewaldi* Knechtel which was collected from Peru and has been deposited in British Museum (Nat. Hist.) under number 37521 by having a large, smooth conch.

Dimensions

Dm	E	H	O
210	62	103	15
160	45	78	19

Genus: *Hemitissotia* Person, 1897

***Hemitissotia turzoi* Karrenberg, 1935**

[Pl. 1, (1-4)]

1935, *Hemitissotia turzoi*, Karrenberg [19], p. 150, Pl. 32, fig. 19; Pl. 33, figs. 20,21.

1949, *Hemitissotia turzoi* Karrenberg, Hourcq [20], P. 104, figs. 1, la.

1977, *Hemitissotia turzoi* Karrenberg, El-Asa'ad [4], P. 304, Pl. 24, figs. 2a, b.

1978, *Hemitissotia turzoi* Karrenberg, Wiedmann J. and Kauffman E.G. [21], P. iii-34, pl. 12, figs. 3a, b.

1979, *Hemitissotia turzoi* Karrenberg, Wiedmann, J. [22], P. 170, pl. 12, figs. 3a, b.

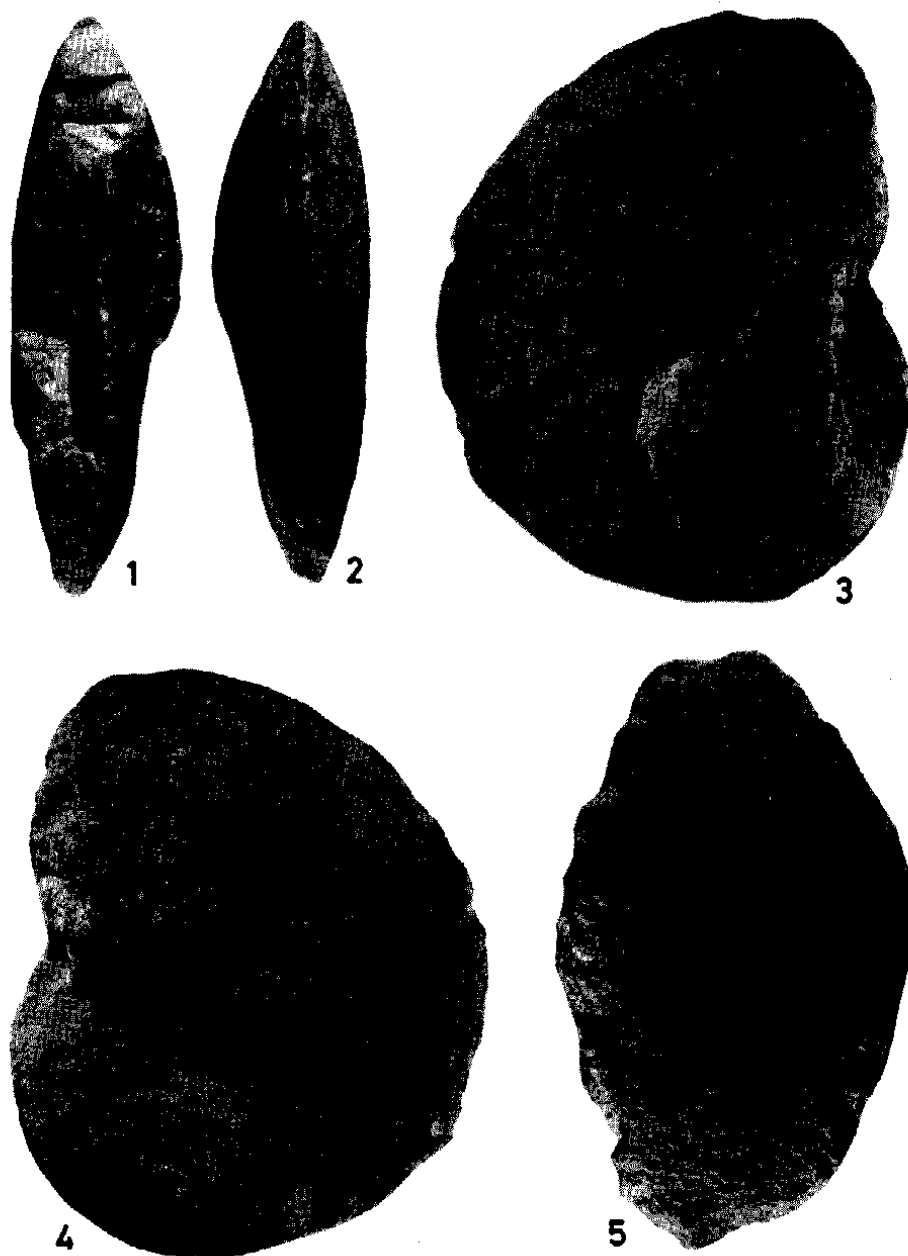


Plate 1, (1-4) *Hemitissotia turzoi* Karrenberg, KSU. G. Amm. 56, from the lower part of the Khanasir Limestone Member, Coniacian, Khashm Rudhai.

(1.1) Apertural view of phragmocone, X1.

(1.2) Ventral view, X1.

(1.3,4) Lateral views, X1.

(1.5). *Manambolites amardi* Collignon and Roman, KSU. G. Amm. 60, from the lower part of the Hajajah Limestone Member, Upper Campanian, Riyadh-Khuras Road, lateral view of incomplete phragmocone, X1.

V. *Hemitissotia turzoi* Karrenberg, in collections of Sedgwick Museum, Cambridge University, No. F-11667 from the lower Senonian of Morocco.

Material

One phragmocone (KSU. G. Amm. 56) was collected from the Khanasir Limestone Member of the Aruma Formation at Khashm Rudhai.

Description

The specimen is medium sized conch, involute, moderately biconvex and with lanceolate whorl section. Venter is sharp with keel and without channels or ridges on either side of the keel. Pseudoceratitic suture line has five saddles. The 1st lateral one is more or less denticulated, the 2nd lateral one is notched and the other lateral saddles are smaller and entire. The 2nd lateral lobe is wider than the other lobes.

Discussion

The present species resembles the following species: *Hemitissotia djelfensis* (Peron) (Hyatt [23], p. 40), *Tissotia djelfensis* Peron (Peron [24], p. 71, Pl. 16, figs. 3,4) and *Tissotia djelfensis* Peron (Specimen deposited in Lyon, I.S.T. under No. 63916 from the Lower Senonian of Algeria). They are similar in their suture line, venter shape and smooth lateral sides but it differs from them in having a biconvex non compressed conch and shallower suture line elements.

Dimensions

Dm: 97; E, 28; H, 60; O, 13.5

Hemitissotia arumaensis Sp. nov.
(Text-Figs. 6,7)

Diagnosis

A species of *Hemitissotia* are characterized by eccentrically coiled, smooth conchs, large body chamber (3/4 volution), simple umbilicus and by an adorally blunt venter.

Derivation of name

It has been named after the Aruma Formation from which it was collected.

Holotype

A complete conch of internal mold (KSU. G. Amm 57)

Paratypes

Two complete conchs of internal molds (KSU G. Amm. 58 and 59).

Other material

Four complete conchs and several incomplete conchs were also collected.

Locality and Horizon

All specimens were collected from the lower part of the Khanasir Limestone Member, Aruma Formation at Khashm Rudhai, Riyadh-Khuraish road, Khashm Buwaibiyat, Khashm Khanasir and Khashm Hajajah, Central Saudi Arabia, (Coniacian).

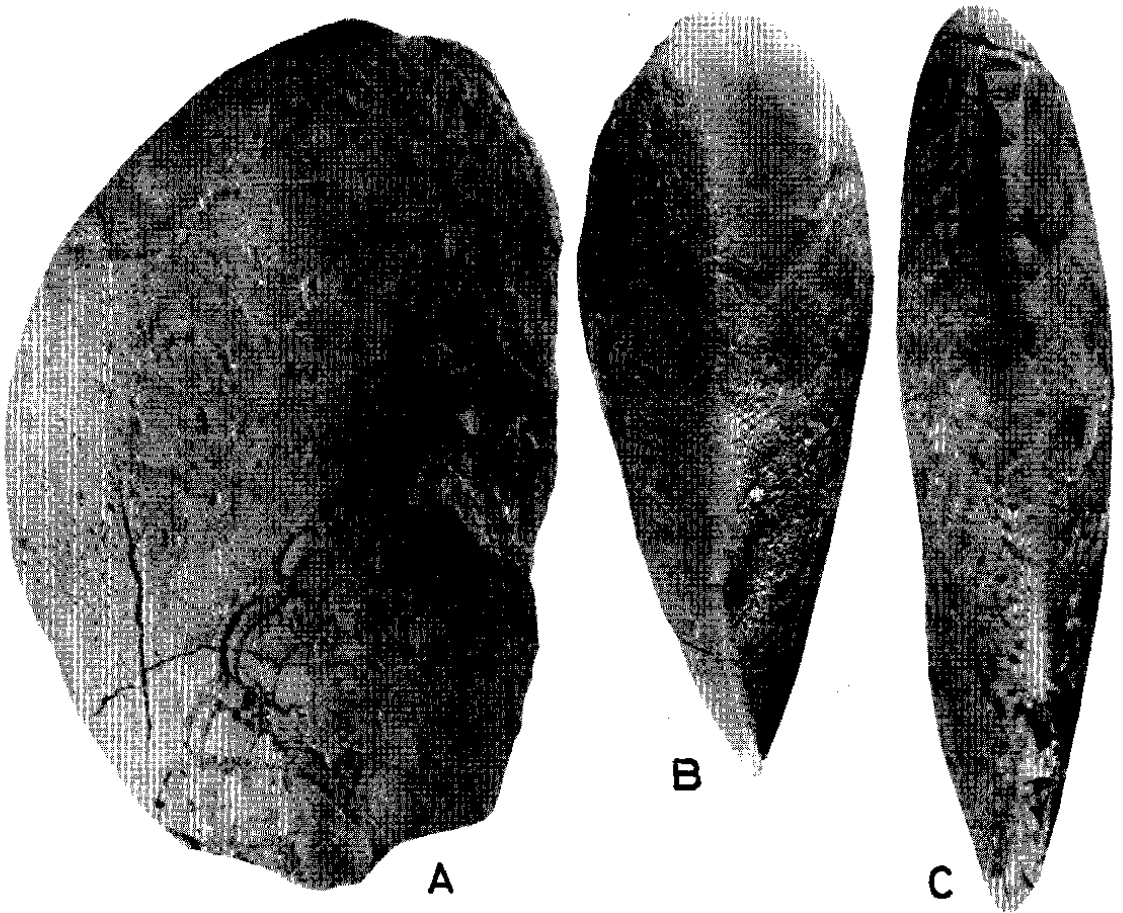


Fig. 6. *Hemitissotia arumaensis* sp. nov., (Figs. 6A, 6B), KSU. G. Amm. 57 (Holotype), from the lower part of the Khanasir Limestone Member Coniacian, Khashm Rudhai; (A) lateral view of complete conch with body, chamber, X-0-5; (B) ventral view, X-0-5; (C) KSU. G. Amm. 58 (Paratype), from the lower part of the Khanasir Limestone Member, Coniacian, Riyadh-Khuraish Road, ventral view, X-0-5.

Description

The specimens are large, highly involute, eccentrically coiled and smooth oxycones. Phragmocone is slightly compressed. Umbilicus is simple and narrow. Large body chamber has length of about $3/4$ of last whorl (volution). It is moderately inflated and adorally contracted. Ventral side adapically acute and become sub-rounded or adorally blunt. Mature conchs with pseudoceratitic suture line have six saddles on each flank. The 1st and the 2nd lateral saddles are notched or weakly incised. The other saddles are low, broad and entire. The last suture lines show some overlapping with truncated lobe endings. The lateral lobes are denticulated. The 2nd lateral lobe is wider than the other lateral lobes.

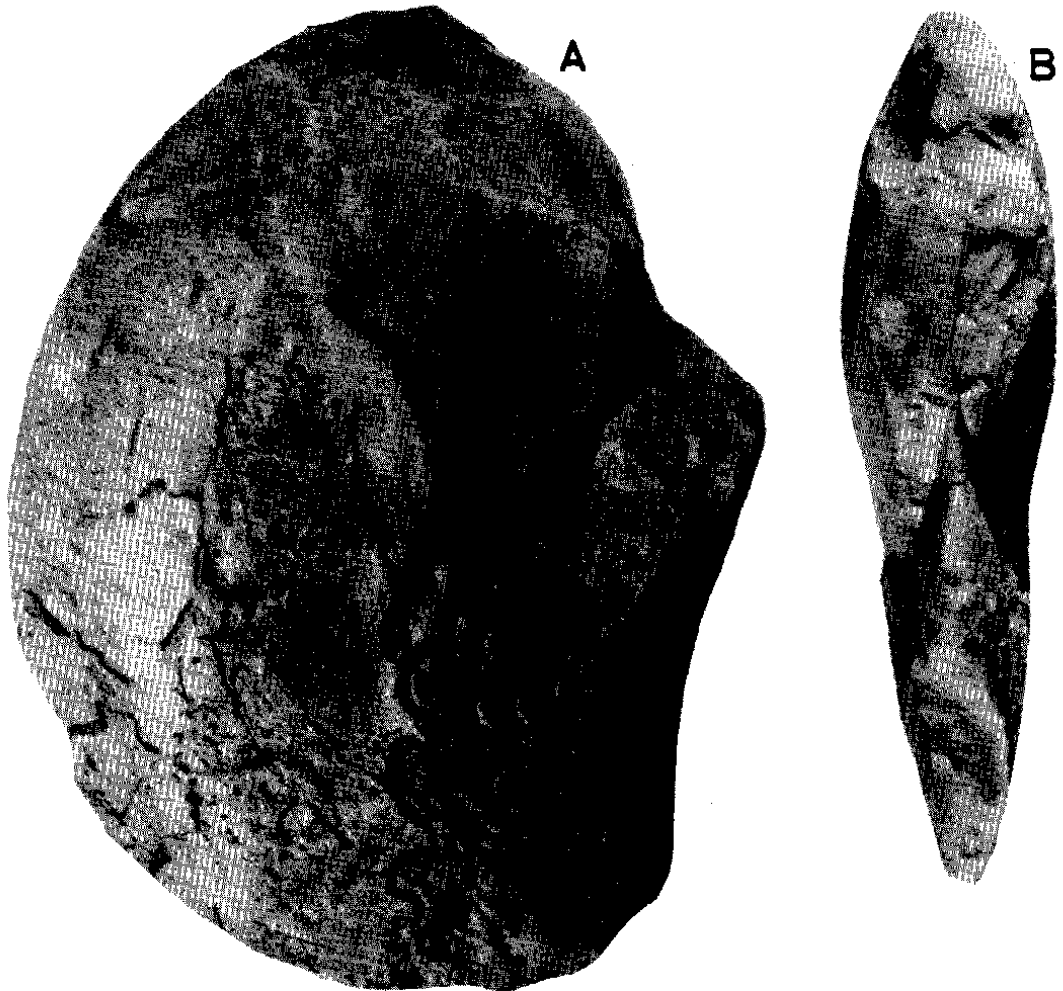


Fig. 7. *Hemitissotia arumaensis* sp. nov., KSU. G. Amm. 58 (Paratype), from the lower part of the Khana-sir Limestone Member, Coniacian, Riyadh-Khuraib Road.

(A) Lateral view with complete body chamber, X-0.6

(B) Apertural view, X-0.5.

Discussion

The present species is similar to *Allotissotia galeppi* (Pervinquiere) which was described by Parnes (Parnes [25]) and that has an eccentrically coiled oxycone shell, large body chamber and smooth conch. However, it differs by having a simple umbilicus without overhanging edge or reclined umbilical wall, and by having simpler suture lines and blunt ventral side. It is similar to some species of the genus *Hemitissotia* Peron, 1897 which have a blunt ventral edge, rounded umbilicus and simpler suture line. It resembles *Hemitissotia ceadouroensis* which was described by Choffat [26], p. 74, pl. 20, figs (7-12) from Portugal, and which is eccentrically coiled and have rounded external parts of the whorl. It is distinguished from both of them by its general form and by its smooth conchs.

Dimensions

	1	2	3	4	5	6
Dm:	210	230	190	143	145	180
E:	40	50	47	38	39	70
H:	100	112	102	70	112	88
O:	15	20	15	—	20	19

Superfamily : *Acanthocerataceae* Hyatt, 1900

Family : *Sphenodiscidae* Hyatt, 1900

Genus : *Manambolites* Hourcq, 1949

***Manambolites amardi*, Collignon, M. and Roman, J., 1981**

(Pl. 1, Fig. 5; Text-Fig. 8A)

1981, *Manambolites amardi*, Collignon, M. and Roman, J. [27], P. 58, Pl. 11, figs. 3,4.

V., *Manambolites amardi*, Collignon, M. and Roman, J. Holotype, No. 1981-7-AB 458-1 in Collection de l'institut de Paléontologie du Muséum d'Histoire Naturelle de Paris.

Material

One specimen of incomplete phragmocone (KSU. G. Amm. 60) was collected from the Hajajah Limestone Member of the Aruma Formation at Riyadh-Khuraish road.

Description

The specimen is medium to large phragmocone, whorl section lanceolate, lat-

eral sides are moderately convex. Ventral side tends to become sharp towards the body chamber. Phragmocone is smooth and partly weathered. Suture line is pseudoceratitic. There are five saddles, the 1st lateral saddle is divided into two branches by a small and narrow adventitious lobe. Both branches of the 1st lateral saddle are more or less indented. The 2nd lateral saddle is notched. The other saddles are entire and have *Tissotia* like shape. They tend to become smaller towards the umbilical region.

Discussion

Although the present specimen is poorly preserved; it can be allocated confidently to *M. amardi* on the basis of its suture line characteristics.

Dimensions

Dm: 98 **E:** 29, **H:** 61 **O:** 12

Family : *Libycoceratidae* Zaborski, 1982

Genus : *Libycoceras* Hyatt, 1900

Libycoceras chargense Blankenhorn, 1900 (Text-Fig. 9A)

1900, *Libycoceras chargense* Blankenhorn [28], P. 45.

1928, *Libycoceras chargense* Blankenhorn, Douvillé [29], P. 33, Pl. 7.

1977, *Libycoceras chargense* Blankenhorn, Lewy [30], P. 246, figs. 3H, I

V. *Libycoceras chargense* Blankenhorn, In British Museum (Natural History) No. C 70657, from Rusayfah-Jordan.

V. *Libycoceras* aff. *chargense* Blankenhorn, In British Museum (Natural History) No. C 71512, from Hedira structure, southern Palestine.

Material

Two phragmocones (KSU. G. Amm. 61; KSU. G. Amm. 62) were collected from the Hajajah limestone Member of the Aruma Formation at Khashm al-Buwaibiyat.

Description

The specimens are discoidal, phragmocone large and involute attaining diameter of about 22 cm. Whorl section is lanceolate with sharp venter and without ventrolateral shoulders. Flanks are smooth and without tubercles. Sutureline is pseudoceratitic. The 1st lateral saddle is notched or bifid with two unindented parts.

The other saddles are entire and rounded. Saddles tend to become smaller from the venter to the umbilicus. It is distinguished by its lanceolate whorl section, lack of ventro-lateral shoulders and by lack of ornamentation.

Discussion

The present specimens of *Libyoceras chargense* differ from *L. ismaeli* (Zittel) in lacking tubercles. They are distinguished from those figured by Lewy [30] which were collected from the top of the Mishash Formation (Late Campanian) by the parts of their 1st lateral notched saddles are unindented. They differ from a specimen of those species deposited in the British Museum (No. 70657) and which are collected from the Upper Campanian of Rusayfah-Jordan, by lacking a ventral Keel. They resemble another specimen of those species deposited in the British Museum No. C 71512 and which are collected from the Upper Maastrichtian of Hedira Structure, southern Palestine.

Dimensions

Dm	E	H	O
148	53	75	18
215	67	135	26

***Libyoceras* sp.**
(Text-Figs. 8B, 9B)

Material

One specimen of phragmocone (KSU. G. Amm. 55) was collected from the Hajajah Limestone Member of the Aruma Formation at Khashm Hajajah.

Description

The specimen is highly involute, inflated, biconvex phragmocone with maximum inflation on umbilical region. Cross-section lanceolate, smooth without traces of ribs or tubercles. umbilicus is moderately deep. Suture line is pseudoceratic. The older suture lines are near to those of *Libyoceras* Hyatt, 1900. The 1st lateral saddle is notched into two entire parts. The ventral part is inclined towards the acute venter. The other saddles are phylliform and entire. The 1st lateral lobe is narrow and with 1/3 width of the 2nd lateral lobe. Lateral lobes are more or less denticulated. Last (younger) suture lines are overlapping with truncated lobe endings (may be a reflection of maturity). They have low, broad, entire saddles and broad shallow lobes. These lobes are less or not denticulated. Ventral lobes are without siphonal saddles.

Discussion

The present species is similar to *Libyoceras ismaeli* Zittel (Specimen No. C 25895 and No. C 258901 which are deposited at the British Museum, Geol. Dept.

These were collected by B.K.N. Whyllie, K.A. Campbell and G.M. Lees of the Turkish Petroleum Co. Ltd., 1924 from the Maastrichtian, south of Jissr ed Debba, west of el Katrain, Trans-Jordan) by having a smooth conch, sharp venter and by its older suture lines being similar to those of *L. ismaeli*; but it differs in having a strongly inflated flanks. It differs from all species of the genus *Libycoceras* Hyatt, 1900 by having a strongly inflated conch (not depressed), smooth conch (without mediolateral or ventrolateral tubercles or rib-like ornament) and by lacking of ventrolateral shoulders. Although populations of the genus *Libycoceras* from the Middle East show considerable variation in breadth of venter and strength of ornament, however, the present species is still distinguished by its high involute and strong inflated oxycone shell.

Dimensions

Dm: 177 E: 105 H: 117 O: 25

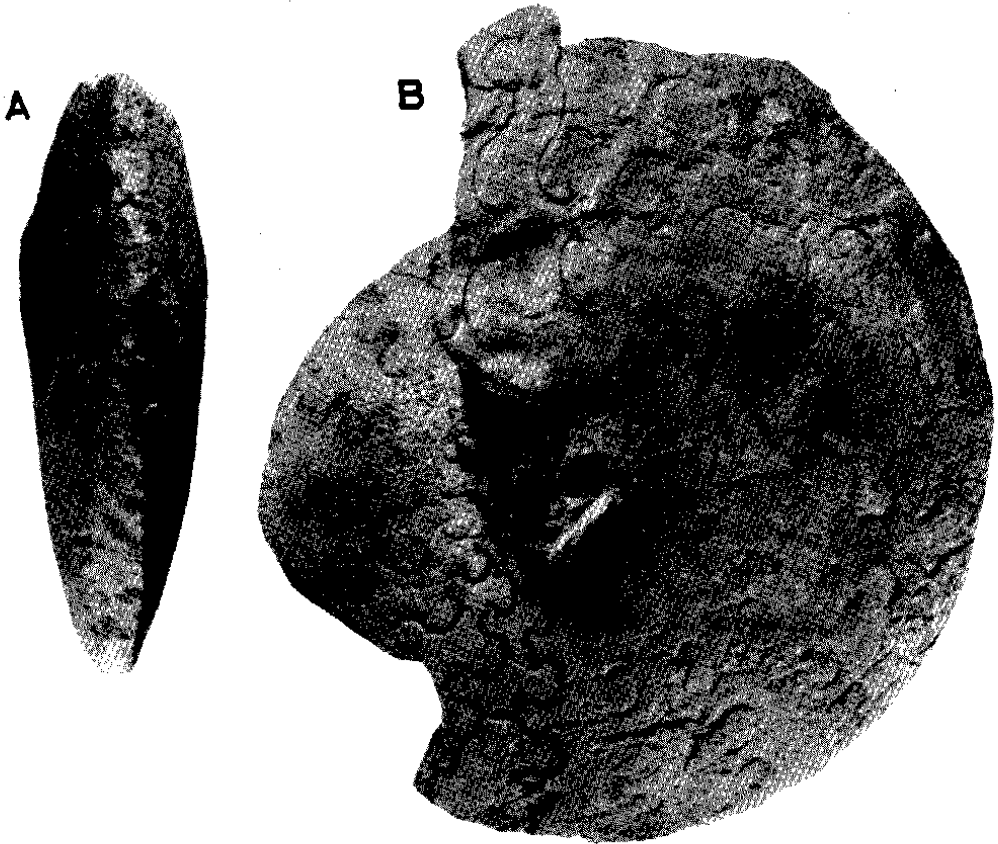


Fig. 8. (A) *Manambolites amardi* Collignon and Roman KSU. G. Amm. 60, from the lower part of the Hajajah Limestone Member, Upper Campanian, Riyadh-Khuraish road, ventral view of incomplete phragmocone, XO. 9.

(B) *Libycoceras* sp. KSU. G. Amm. 55, from the upper part of the Hajajah Limestone Member, Upper Campanian, Khashm Hajajah, lateral view of phragmocone, XO. 6.

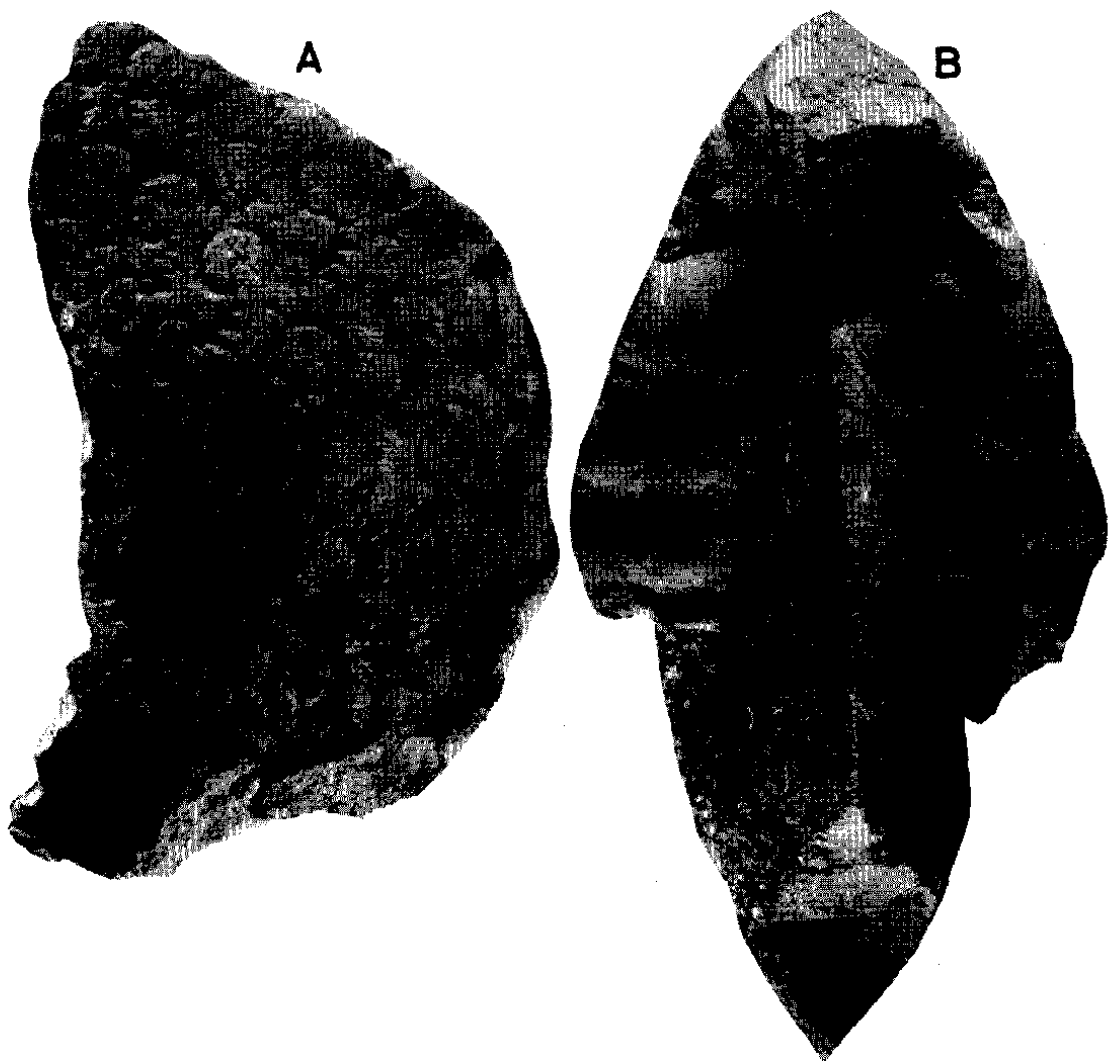


Fig. 9 (A) *Libycoceras chargense* Blankenhorn, KSU. G. Amm. 61, from the lower part of the Hajajah Limestone Member, Upper Campanian, Khashm Buwalbiyat. lateral view of incomplete phragmocone, $\times 0.8$

(B) *Libycoceras* sp. KSU. G. Amm. 55, from the upper part of the Hajajah Limestone Member, Upper Campanian, Khashm Hajajah, apertural view of phragmocone, XO. 8.

Discussion

The following ammonite species: *Pachydesmoceras* sp., *Metastissotia* cf. *ewaldi* (Von Buch), *Hemitissotia turzoi* Karrenberg and *H. arumaensis* sp. nov. were collected from the lower ten meters of the nodular limestone of the Khanasir Limestone Member which are equivalent to the *Tissotia* assemblage zone El-Asa'ad [4,6].

The genus *Pachydesmoceras* spath, 1922 was recorded from the Cenomanian-Coniacian of Madagascar by Collignon [9], from southern India by Stoliczka (op. cit.) [31] and by Matsumoto [10] from Japan. *Hemitissotia turzoi* Karrenberg was identified by Karrenberg [19], and was recorded by Weidmann and Kauffman [21] and by Wiedmann [22] from the Upper Coniacian of Northern Spain. It was also recorded by Hourcq [20] from the Senonian of Madagascar. *Metatissotia* cf. *ewaldi* (Von Buch) was identified by Luger and Gröschke [18] from the Middle or Late Coniacian of the Egyptian eastern desert. *Metatissotia ewaldi* (Von Buch) was recorded by Kennedy [17] from the Middle Coniacian of France, Northern Spain and Austria. It was also reported from the Late Coniacian of Sinai by Lewy and Raab [32]. The genera *Metatissotia* Hyatt, 1903 and *Hemitissotia* Peron, 1987 are members of the family Tissotiidae Hyatt, 1900; this family had a widespread distribution, mainly during Turonian-Coniacian time from the Tethyan Realm especially in North and East Africa, the Middle East, central and South America, Texas and Spain (Bayle [33], Douvillé [29], Peron [24], Hyatt [23], Reyment [34], Barber [35], Collignon [36], Freund and Raab [37], Choffat [26] and Benavides-Cáceres [38]).

According to these ammonite species, the lower part of the Khanasir Limestone Member is assigned to Middle-Late Coniacian age.

The rudistid reefal limestone yields an abundant Campanian rudist fauna; these comprise *Dictyoptychus morgani*; *Durania cornupastoris*, *D. gaensis* and *Biradiolites lumbricalis*, El-Asa'ad and Skelton [39].

El-Asa'ad [6] identified two larger forams from the top of the Khanasir Limestone Member, just below the olive, green shale unit (6m thick). These larger forams are: *Monolepidorbis sanctae pelagiae* Astré and *Orbitoides tissoti* Schlumberger. The first species has been recorded by different authors from the Campanian of Organya, Spain, while the second species has been recorded from the Campanian of Algeria, Tunisia, France and West Pakistan (El-Asa'ad [6]).

According to the rudist fauna and the two larger forams from the top of the Khanasir Limestone Member; a Lower-Middle Campanian age is here assigned to the upper part of the member.

From just above the olive, green shale unit (6m thick) at the base of the Hajajah limestone Member, El-Asa'ad [6] identified several species of larger forams: *Monolepidorbis douvillei* Astré, *Orbitoides gensasicus* Leymerie, *O. apiculatus* Schlumberger, *Lepidorbitoides macgillavryi* Thiadens, *L. (Asterobsis) rooki* Vaughan and Cole and *Omphalocyclus macroporous* (Lamarck). Of these, *Omphalocyclus macroporous* ranges and up through the Hajajah Limestone Member and the whole of the Lina shale Member, it has the most restricted range and is occurring within the Maastrichtian (not the earliest part, Van Gorsel [40, p. 120]).

Manambolites amardi Collignon and Roman and *Libycoceras chargense* Blankenhorn were collected from the basal part of the slightly dolomitic, chalky limestone (51m thick) of the Hajajah limestone Member, while *Pachydiscus (Pachydiscus) launayi* (de Grossouvre) and *Libycoceras* sp. were collected from the upper part of the slightly dolomitic, chalky limestone.

Collignon and Roman [27] identified *Manambolites amardi* from an Upper Campanian level in the Algerian Sahara (Gour Taguentourt section). They reported that the genus *Manambolites* Hourcq, 1949 is strictly localized at the top of the Middle Campanian in Madagascar.

Lewy [30] recorded *Libycoceras chargense* from Palestine at the top of the Mishash Formation in the uppermost flint layers and phosphorite beds above. These phosphorite beds are also known from the Rusayfah phosphorite mines near Amman in Jordan and also from several localities in Egypt and Northern Africa. Phosphorite beds in Palestine and Egypt were dated by foraminifera as of Late Campanian age; and have the biostratigraphic equivalent of the *Bostrychoceras polyplacum* zone, Reiss [41]. According to Reiss [41], Lewy [30] and Zaborski [8] the *Libycoceras* species from Palestine, Jordan and southern Nigeria may have lived in Late Campanian time in isolated marine basins of abnormal bottom conditions.

Pachydiscus (Pachydiscus) launayi was recorded by Kennedy [11] from the Upper Campanian of northern Aquitaine, France. It is well known from the Upper Campanian of north Germany, Poland, Sweden, Donbass, Kopet Dag and elsewhere in the U.S.S.R., Kennedy [11].

According to the presence of *Manambolites amardi* Collignon and Roman, *Libycoceras chargense* Blankenhorn and *Pachydiscus (pachydiscus) launayi* (de Grossouvre) in the slightly dolomitic, chalky limestone; a Late Campanian is suggested here to this rock unit.

Consideration of the present ammonite species and their ranges from the Late Cretaceous sequence in Central Saudi Arabia (Aruma Formation) together with the absence of planktic foraminifera led to the recognition of a big hiatus between the rudistid reefal limestone (Lower-Middle Campanian) and the underlying nodular limestone (Coniacian). This hiatus may be attributed to tectonic tilt and possible Late Coniacian global drops of sea level which left the top of the nodular limestone truncated below the rudistid reefal limestone. Such truncated surfaces can be traced over the entire Middle East (Gvirtzman et al. [42]).

El-Asa'ad [43] identified *Loftusia arabica* El-Asa'ad which was collected from localized calcareous facies within the olive, green shale unit (6m. thick) at the base of the Hajajah Limestone Member. From adjacent areas such as Iran, Oman, Iraq

and Turkey; *Loftusia* species are always found associated with Maastrichtian faunal assemblages (El-Asa'ad [43]).

The present work suggests that the two larger forams; *Loftusia arabica* El-Asa'ad and *Omphalocyclus macroporous* (Lamarck) from the Hajajah Limestone Member are of Campanian age. Consequently, the Campanian-Maastrichtian boundary in Central Saudi Arabia in ammonite terms is drawn here at a different level than that previously based on larger forams (Fig. 2).

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أمونيات الطباشيري المتأخر في وسط المملكة العربية السعودية

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(استلم في ٧ ربيع الآخر ١٤١٠هـ، قُبل للنشر في ١٢ ربيع الآخر ١٤١١هـ)

ملخص البحث. في هذا البحث جرى تعريف ووصف ثمانية أنواع من الأمونيات (واحد منها اعتبر نوعاً جديداً) جمعت من عضوي الخناصر والحجاجا الجيريين من متكون العرمة في وسط المملكة العربية السعودية.

تتألف هذه الأمونيات من الأنواع التالية:

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بعد تعريف أنواع الأمونيات ومقارنتها وتحديد أعمارها الجيولوجية فقد أمكن تحديد العمر الجيولوجي لعضو الخناصر الجيري (كونيسي) وعضو الحجاجا الجيري (كامباني أوسط - كامباني علوي).

تستنتج هذه الدراسة وجود ثغرة ترسيبية بين عمري الكونيسي والكامباني تشمل عمر السانتوني والكامباني السفلي وترجع هذه الثغرة إلى الخللخالات التكتونية والهبوط العام في مستوى مياه البحار خلال عمر الكونيسي المتأخر. كما تستنتج هذه الدراسة أن الحدود الفاصلة بين عمري الكامباني والماسترختي في وسط المملكة العربية السعودية والمبني على وجود الأمونيات تختلف تماماً عنها إذا بنيت على وجود أحافير الفورامينيفرا الكبيرة.